VII. *Account of experiments made on the strength of materials. By* George Rennie, *jun. Esq. In a Letter to* Thomas Young, *M. D. For. Sec. R. S.*

Read February 12th, 1818.

DEAR SIR, *London, June* 3, 1817.

In presenting you the result of the following experiments, I trust I shall not be considered as deviating from my subject, in taking a cursory view of the labours of others. The knowledge of the properties of bodies which come more immediately under our observation, is so instrumental to the progress of science, that any approximation to it deserves our serious attention. The passage over a deep and rapid river, the construction of a great and noble edifice, or the combination of a more complicated piece of mechanism, are arts so peculiarly subservient to the application of these principles, that we cannot be said to proceed with safety and certainty, until we have assigned their just limits. The vague results, on which the more refined calculations of many of the most eminent writers are founded, have given rise to such a multiplicity of contradictory conclusions, that it is difficult to choose, or distinguish, the real from that which is merely specious. The connections are frequently so distant, that little reliance can be placed on them. The Royal Society appears to have instituted, at an early period, some experiments on this subject, but they have recorded little to aid us. Emerson, in his Mechanics, has laid down a number of rules,

and approximations. Professor ROBISON in his excellent treatise in the Encyclopædia Britannica; BANKS on the power of machines; Dr. ANDERSON of Glasgow; Colonel BEAUFOY, &c. are those, amongst our countrymen, who have given the result of their experiments on wood, and iron. The subject, however, appears to have excited considerable attention on the continent. A theory was published in the year 1638, by GALILEO, on the resistance of solids, and subsequently, by many other philosophers. But however plausible these investigations appeared, they were more theoretical than practical, as will be seen in the sequel. It is only by deriving a theory from careful and well directed experiments, that practical results can be obtained. It would be useless to enumerate the labours of those philosophers, who in following, or varying from the steps of GALILEO, have merely tended to obscure a subject respecting which they had no data to proceed upon. It is sufficient to enumerate the names of those who, in conjunction with our own countrymen, have added their labours to the little knowledge we possess. The experiments of BUFFON, recorded in the Annals of the Academy of Sciences at Paris, in the years 1740 and 1741, were on a scale sufficiently large to justify every conclusion, had he not omitted to ascertain the direct and absolute strength of the timber employed. It however appeared from his experiments, that the strength of the ligneous fibre is nearly in proportion to the specific gravity. MUSCHENBROECK, whose accuracy (it is said) entitled him to confidence, made a number of experiments on wood and iron, which by being tried on various specimens of the same materials, afforded a mean result considerably higher than other previous authorities. Experiments have

also been made by Mariotte, Varignon, Perronet, Ramus, Rondelet, Gauthey, Navier, Aubry and Texier de Norbeck, as also at the Ecole Polytechnique, under the direction of M. Prony. With such authorities before us, it might be deemed presumption in me, to offer you a communication on a subject which had been previously treated of by so many able men. But whoever has had occasion to investigate the principles upon which any edifice is constructed, where the combination of its parts are more the result of uncertain rules than sound principle, will soon find how scanty is our knowledge on a subject so highly important. The desire of obtaining some approximation, which could only be accomplished by repeated trials on the substances themselves, induced me to undertake the following experiments; for which purpose I ordered an apparatus to be prepared, of which the two annexed plates [Plates VI. and VII.] are representations.

Description of the Apparatus.

A bar of the best English iron, about 10 feet long, was selected and formed into a lever (whose fulcrum is denoted by f). The hole was accurately bored, and the pin turned, which suffered it to move freely. The standard (A) was firmly secured by the nut (c) to a strong bed plate of cast iron, made firm to the ground. The lever was accurately divided in its lower edge, which was made straight in a line with the fulcrum. A point, or division (D), was selected, at 5 inches from the fulcrum, at which place was let in a piece of hardened steel. The lever was balanced by the balance weight (E), and in this state it was ready for operation. But in order to keep it as level as possible, a hole was drilled

through a projection on the bed plate, large enough to admit a stout bolt easily through it, which again was prevented from turning in the hole by means of a tongue (*t*) fitting into a corresponding groove in the hole. So that, in order to preserve the level, we had only to move the nut to elevate, or depress the bolt, according to the size of the specimen. But as an inequality of pressure would still arise from the nature of the apparatus, the body to be examined was placed between two pieces of steel, the pressure being communicated through the medium of two pieces of thick leather above, and below the steel pieces, by which means a more equal contact of surfaces was attained. The scale was hung on a loop of iron, touching the lever in an edge only. I at first used a rope for the balance weight, which indicated a friction of four pounds, but a chain diminished the friction one half. Every moveable centre was well oiled. Of the resistances opposed to the simple strains which may disturb the quiescent state of a body, the principal are the repulsive force, whereby it resists compression, and the force of cohesion, whereby it resists extension. On the former, with the exception of the experiments of GAUTHEY and RONDELET, on stones, and a few others, on soft substances, there is scarcely any thing on record. In the memoir of M. LAGRANGE, on the force of springs, published in the year 1760, the moment of elasticity is represented by a constant quantity, without indicating the relation of this value to the size of the spring: but, in the memoir of the year 1770, on the forms of columns, where he considers a body whose dimensions and thickness are variable, he makes the moment of elasticity proportional to

the fourth power of the radius, in observing the relations of theory and practice to accord with each other. This was admitted by Euler in his memoir of 1780, in his elaborate investigation of the forms of columns. Mr. Coulomb had however shown before that time, how inapplicable all these calculations were to columns under common circumstances; and you, Sir, have repeated the observation in your lectures on natural philosophy. The results of experiments have also been equally discordant; since it is deduced from those of Reynolds, that the power required to crush a cubic quarter of an inch of cast iron, is 448000lbs. avoirdupoise, or 200 tons; whereas by the average of thirteen experiments made by me on cubes of the same size, the amount never exceeded 10392.53lbs, not quite five tons.* This may be seen by referring to the tables. There were four kinds of iron used, viz. 1st. iron taken from the centre of a large block, whose crystals were similar in appearance and magnitude to those evinced in the fracture of what is usually termed gun metal. 2ndly. Iron taken from a small casting, close grained, and of a dull grey colour. 3rdly. Iron cast horizontally in bars of $\frac{3}{8}$th inches square, 8 inches long. 4thly. Iron cast vertically, same size as last. These castings were reduced equally on every side to $\frac{1}{4}$ of an inch square: thus removing the hard external coat usually surrounding metal castings. They were all subjected to a gauge. The bars were then presumed to be

* It is probable that Mr. Reynolds made his experiments on metal cast at the furnace of Maidley Wood, which is of a very strong and superior quality; but this circumstance can have been but of little importance compared to the great disproportion of the results.

tolerably uniform. The weights used were of the best kind that could be procured, and as the experiment advanced, smaller weights were used.

Experiments on cast iron in cubes of $\frac{1}{8}$ of an inch, &c.

Iron taken from the block whose specific gravity was 7,033.

Averages.		lbs. avoirdupoise.
1439.66	$\frac{1}{8} \times \frac{1}{8}$ - - - -	1454
	$\frac{1}{8} \times \frac{1}{8}$ - - - -	1416
	$\frac{1}{8} \times \frac{1}{8}$ - - - -	1449

On specimens of different lengths. Specific gravity of iron 6,977.

2116	$\frac{1}{8} \times \frac{2}{8}$ - - - -	1922
	$\frac{1}{8} \times \frac{2}{8}$ - - -	2310
1758.5	$\frac{1}{8} \times \frac{3}{8}$ slipped with 1863lbs. filed flat, and crushed with - -	2363
	$\frac{1}{8} \times \frac{4}{8}$ ditto, 1,495, ditto -	2005
	$\frac{1}{8} \times \frac{5}{8}$ ditto, - - -	1407
	$\frac{1}{8} \times \frac{6}{8}$ ditto, - - -	1743
	$\frac{1}{8} \times \frac{7}{8}$ ditto, - - -	1594
	$\frac{1}{8} \times \frac{8}{8}$ ditto, - - - -	1439

April 23d, 1817. Experiments on cubes of $\frac{1}{4}$ of an inch taken from the block.

9773.5	$\frac{1}{4} \times \frac{1}{4}$ - - - -	10561
	$\frac{1}{4} \times \frac{1}{4}$ - - -	9596
	$\frac{1}{4} \times \frac{1}{4}$ - - - -	9917
	$\frac{1}{4} \times \frac{1}{4}$ - - -	9020

Castings, Horizontal. Specific gravity 7.113.

Averages.		lbs. avoirdupoise.
10114	$\frac{1}{4} \times \frac{1}{4}$ - - - -	10432
	$\frac{1}{4} \times \frac{1}{4}$ - - - -	10720
	$\frac{1}{4} \times \frac{1}{4}$ - - -	10605
	$\frac{1}{4} \times \frac{1}{4}$ - - - -	8699

Vertical castings. Specific gravity 7.074.

1113675	$\frac{1}{4} \times \frac{1}{4}$ bottom of vertical bar -	12665
	$\frac{1}{4} \times \frac{1}{4}$ - - - -	10950
	$\frac{1}{4} \times \frac{1}{4}$ - - -	11088
	$\frac{1}{4} \times \frac{1}{4}$ - - - -	9844
	$\frac{1}{4} \times \frac{1}{4}$ full size. Scale broke with 10294; tried again - -	11006

A prism, having a logarithmic curve for its limits, resembling a column; it was $\frac{1}{4}$ of an inch diameter by one inch long, broke with - - - 6954

April 28*th. Trials on prisms of different lengths.*

9414.5	$\frac{1}{4} \times \frac{1}{2}$ horizontal - - -	9455
	$\frac{1}{4} \times \frac{1}{2}$ ditto - - - -	9374
	$\frac{1}{4} \times \frac{1}{2}$ ditto, bad trial, 9006 lbs.	
9982.5	$\frac{1}{4} \times \frac{1}{2}$ vertical - - -	9938
	$\frac{1}{4} \times \frac{1}{2}$ ditto - - - -	10027

April 29th. *Horizontal Castings.*

Averages.		lbs. avoirdupoise.
$\frac{1}{4} \times \frac{3}{8}$	- - - -	9006
$\frac{1}{4} \times \frac{5}{8}$	- - -	8845
$\frac{1}{4} \times \frac{6}{8}$	- - - -	8362
$\frac{1}{4} \times \frac{7}{8}$	- - -	6430
$\frac{1}{4} \times \frac{8}{8}$ or one inch long	- -	6321

Vertical castings.

$\frac{1}{4} \times \frac{3}{8}$	- - - -	9328
$\frac{1}{4} \times \frac{5}{8}$	- - -	8385
$\frac{1}{4} \times \frac{6}{8}$	a small defect in the specimen -	7896
$\frac{1}{4} \times \frac{7}{8}$	- - - -	7018
$\frac{1}{4} \times \frac{8}{8}$ or one inch	- - -	6430

Experiments on different metals.

$\frac{1}{4} \times \frac{1}{4}$ cast copper, crumbled with	-	-	7318
$\frac{1}{4} \times \frac{1}{4}$ fine yellow brass reduced	$\frac{1}{10}$ with 3213.	$\frac{1}{2}$ with	10304
$\frac{1}{4} \times \frac{1}{4}$ wrought copper, -	$\frac{1}{16}$	3427. $\frac{1}{8}$	6440
$\frac{1}{4} \times \frac{1}{4}$ cast tin, -	$\frac{1}{16}$	552. $\frac{1}{3}$	966
$\frac{1}{4} \times \frac{1}{4}$ cast lead, - - -		$\frac{1}{2}$	483

The anomaly between the three first experiments on $\frac{1}{8}$ cubes, and the two second of a different length, can only be accounted for, on the difficulty of reducing such small specimens to an equality. The experiments on $\frac{1}{8}$ inch prisms of different lengths give no ratio. The experiments on $\frac{1}{4}$ inch cubes, taking an average of the three first in each, give a proportion between them and the three on $\frac{1}{8}$ cubes,

as 1 : 6.096 in the block castings
as 1 : 7.352 in the horizontal ditto
as 1 : 8.035 in the vertical ditto

in several cases the proportion is as the cubes.

The vertical cube castings are stronger than the horizontal cube castings.

The prisms usually assumed a curve similar to a curve of the third order, previous to breaking.

The experiments on the different metals, give no satisfactory results. The difficulty consists in assigning a value to the different degrees of diminution. When compressed beyond a certain thickness, the resistance becomes enormous.

Experiments on the suspension of bars.

The lever was used as in the former case, but the metals were held by nippers, as indicated in the drawing No. 2. They were made of wrought iron, and their ends adapted to receive the bars, which, by being tapered at both extremities, and increasing in diameter from the actual section (if I may so express it), and the jaws of the nippers being confined by a hoop, confined both. The bars, which were six inches long, and ¼ square, were thus fairly and firmly grasped.

April 30*th*, 1817.

		lbs.	
No. 45	¼ inch, cast iron bar, horizontal -	1166	1193.5
46	¼ do. do. vertical -	1218	
47	¼ do. cast steel previously tilted -	8391	
48	¼ do. blister steel, reduced per hammer	8322	
49	¼ do. shear steel, do. do. -	7977	
50	¼ do. Swedish iron, do. do. -	4504	
51	¼ do. English iron, do. do. -	3492	
52	¼ do. hard gun metal, mean of two trials	2273	
53	¼ do. wrought copper reduced per hammer - -	2112	
54	¼ do. cast copper - -	1192	

No. 55	$\frac{1}{4}$ do. fine yellow brass	1123
56	$\frac{1}{4}$ do. cast tin	296
57	$\frac{1}{4}$ do. cast lead	114

Remarks on the last experiments.

The ratio of the repulsion of the horizontal cast cubes to the cohesion of horizontal cast bars, is 8.65 : 1.

The ratio of the vertical cast cubes to the cohesion of the vertical cast bars, is as 9.14 : 1.

The average of the bars, compared with the cube, No. 16, is as 10.611 : 1.

The other metals decrease in strength, from cast steel to cast lead.

The stretching of all the wrought bars indicated heat.

The fracture of the cast bars was attended with very little diminution of section, scarcely sensible.

The experiment made by M. PRONY, (which asserts, that by making a slight incision with the file, the resistance is diminished one half) was tried on a $\frac{1}{4}$ inch bar of English iron; the result was 2920lbs., not a sixth part less.

This single experiment, however, does not sufficiently disprove the authority of that able philosopher, for an incision is but a vague term. The incision I made might be about the 40th part of an inch.

Experiments on the twist of $\frac{1}{4}$ inch bars.

To effect the operation of twisting off a bar, another apparatus was prepared: it consisted of a wrought iron lever two feet long, having an arched head about $\frac{1}{6}$ of a circle, of 4 feet diameter, of which the lever represented the radius, the

centre round which it moved had a square hole made to receive the end of the bar to be twisted. The lever was balanced as before, and a scale hung on the arched head; the other end of the bar being fixed in a square hole in a piece of iron, and that again in a vice. The undermentioned weights represent the quantity of weight put into the scale.

May 30*th*, 1817.

On twists close to the bearing, cast horizontal.

No.		lbs.	oz.	
58	$\frac{1}{4}$ in bars, twisted as under with	10	14	in the scale.
59	$\frac{1}{4}$ do. bad casting - -	8	4	
60	$\frac{1}{4}$ do. - - -	10	11	
	average	9	15	

Cast vertical.

		lbs.	oz.
61	$\frac{1}{4}$ - - -	10	8
62	$\frac{1}{4}$ - - -	10	13
63	$\frac{1}{4}$ - - -	10	11
		10	10

On different metals.

		lbs.	oz.
64	Cast steel - -	17	9
65	Shear steel - -	17	1
66	Blister steel - -	16	11
67	English iron, wrought -	10	2
68	Swedish iron, wrought - -	9	8
69	Hard gun metal -	5	0
70	Fine yellow brass -	4	11
71	Copper, cast - -	4	5
72	Tin - -	1	7
73	Lead - - -	1	0

On twists of different lengths.

No.	Horizontal.	Weight in scale.	
74	$\frac{1}{4}$ by $\frac{1}{2}$ long - - -	7	3
75	$\frac{1}{4}$ by $\frac{3}{4}$ do. - - - -	8	1
76	$\frac{1}{4}$ by 1 inch do. - - -	8	8
	Vertical.		
77	$\frac{1}{4}$ by $\frac{1}{2}$ do. - - -	10	1
78	$\frac{1}{4}$ by $\frac{3}{4}$ do. - - -	8	9
79	$\frac{1}{4}$ by 1 inch do. - - -	8	5

Horizontal twists at 6 from the bearing.

80	$\frac{1}{4}$ by 6 inches long - -	10	9
81	$\frac{1}{4}$ by do. do. - - -	9	4
82	$\frac{1}{4}$ by do. do. - - -	9	7

Twists of $\frac{1}{2}$ inch square bars, cast horizontally.

		qrs.	lbs.	oz.	
83	$\frac{1}{2}$ close to the bearing	3	9	12	end of the bar hard.
84	$\frac{1}{2}$ do. - -	2	18	0	middle of the bar.
85	$\frac{1}{2}$ at 10 inches from bearing, lever in the middle	1	24	0	

On twists of different materials.

These experiments were made close to the bearing, and the weights were accumulated in the scale until the substances were wrenched asunder.

86	Cast steel - - -	19	9
87	Shear steel - - -	17	1
88	Blister steel - - -	16	11
89	English iron, No. 1. - -	10	2

No.		Weight in scale.	
90	Swedish iron - - -	9	8
91	Hard gun metal - - -	5	0
92	Fine yellow brass - -	4	11
93	Copper - - - -	4	5
94	Tin - - -	1	7
95	Lead - - - -	1	0

Remarks.

Here the strength of the vertical bars still predominates.

The average of the two taken conjointly, and compared with a similar case of ½ inch bars, gives the ratio as the cubes, as was anticipated.

In the horizontal castings of different lengths, the balance is in favour of the increased lengths; but in the vertical castings, it is the reverse. In neither is there any apparent ratio. In the horizontal castings at 6 inches from the bearing, there is a visible increase, but not so great as when close to the bearing.

June 4th, 1817. Miscellaneous experiments on the crush of one cubic inch.

No.		lbs. avoirdupoise.
96	Elm - - - -	1284
97	American pine - - -	1606
98	White deal - -	1928
99	English oak, mean of two trials -	3860
100	Ditto, of 5 inches long, slipped with -	2572
101	Ditto, of 4 inches do. - -	5147
102	A prism of Portland stone 2 inches long -	805
103	Ditto, statuary marble - -	3216
104	Craig Leith - - -	8688

In the following experiments on stones, the pressure was communicated through a kind of pyramid, the base of which rested on the hide leather, and that, on the stone. The lever pressed upon the apex of the pyramid. Cubes of one and a half inch.

		specific gravity.	lbs. avoirdu.
105	Chalk - - - -		1127
106	Brick of a pale red colour -	2.085	1265
107	Roe stone, Gloucestershire - -		1449
108	Red brick, mean of two trials -	2.168	1817
109	Yellow face baked Hammersmith paviors 3 times		2254
110	Burnt do. mean of two trials - -		3243
111	Stourbridge or fire brick - -		3864
112	Derby grit, a red friable sand stone	2.316	7070
113	Ditto, from another quarry -	2.428	9776
114	Killaly white freestone, not stratified	2.423	10264
115	Portland - -	2.428	10284
116	Craig Leith, white freestone -	2.452	12346

June 5th, 6th, and 7th, 1817.

117	Yorkshire paving with the strata	2.507	12856
118	Ditto, do. against the strata -	2.507	12856
119	White statuary marble not veined	2.760	13632
120	Bramley Fall sand stone, near Leeds, with strata - -	2.506	13632
121	Ditto, against the strata -	2.506	13632
122	Cornish granite - -	2.662	14302
123	Dundee sand stone or Brescia, two kinds - - -	2.530	14918
124	A two inch cube of Portland -	2.423	14918

No.		specific gravity.	lbs. avoir.
125	Craig Leith with the strata -	2.452	15560
126	Devonshire red marble, variegated		16712
127	Compact limestone - -	2.584	17354
128	Peterhead granite hard close grained		18636
129	Black compact limestone, Limerick	2.598	19924
130	Purbeck - -	2.599	20610
131	Black Brabant marble -	2.697	20742
132	Very hard freestone -	2.528	21254
133	White Italian veined marble -	2.726	21783
134	Aberdeen granite, blue kind -	2.625	24556

N. B. The specific gravities were taken with a delicate balance, made by Creighton of Glasgow, all with the exception of two specimens which were by accident omitted.

Remarks.

In observing the results presented by the preceding table, it will be seen that little dependence can be placed on the specific gravities of stones, so far as regards their repulsive powers, although the increase is certainly in favour of their specific gravities. But there would appear to be some undefined law in the connection of bodies, with which the specific gravity has little to do. Thus, statuary marble has a specific gravity above Aberdeen granite, yet a repulsive power not much above half the latter. Again, hardness is not altogether a characteristic of strength, inasmuch as the limestones, which yield readily to the scratch, have nevertheless a repulsive power approaching to granite itself.

It is a curious fact in the rupture of amorphous stones, that pyramids are formed, having for their base the upper side of the cube next the lever, the action of which displaces the

sides of the cubes, precisely as if a wedge had operated between them. I have preserved a number of the specimens, the sides of which, if continued, might cut the cubes in the direction of their diagonals.

Experiments made on the transverse strain of cast bars, the ends loose. June 8*th*, 1817.

		Weight of the bars. lbs.	oz.	Dist. of bearings ft.		lbs. avoir.
135	Bar of 1 inch square	10	6	3	0	897
136	Do. of 1 inch, do.	9	8	2	8	1086
137	half the above bar			1	4	2320
138	Bar of 1 inch square, through the diagonal	2	8	2	8	851
139	Half the above bar			1	4	1587
140	Bar of 2 in. deep, by $\frac{1}{2}$ inch thick	9	5	2	8	2185
141	Half the above bar			1	4	4508
142	Bar 3 in. deep, by $\frac{1}{3}$ inch thick	9	15	2	8	3588
143	Half the bar			1	4	6854
144	Bar 4 inches, by $\frac{1}{4}$ inch thick	9	7	2	8	3979
145	Equilateral triangles with the angle up and down.					
146	Edge or angle up	9	11	2	8	1437
147	——— angle down	9	7	2	8	840
148	Half the first bar			1	4	3059
149	Half the second bar			1	4	1656
150	A feather-edged or ⊥ bar was cast whose dimensions were					
151	2 inches deep by 2 wide	10	0 edge up	2	8	3105
152	Half of ditto					

N. B. All these bars contained the same area, though differently distributed as to their forms.

Experiments made on the bar of 4 inches deep by ¼ inch thick, by giving it different forms, the bearings at 2 feet 8 inches, as before.

		lbs.	lbs.
153	Bar formed into a semi-ellipse, weighed	7	4000
154	Ditto, parabolic on its lower edge	-	3860
	Ditto, of 4 inches deep by ¼ inches thick	-	3979

Experiments on the transverse strain of bars, one end made fast, the weight being suspended at the other, at 2 feet 8 inches from the bearing.

155	An inch square bar bore	- -	280
156	A bar 2 inches deep, by ½ an inch thick	-	539
157	An inch bar, the ends made fast	- -	1173

The paradoxical experiment of EMERSON was tried, which states that by cutting off a portion of an equilateral triangle (see page 114 of EMERSON'S Mechanics) the bar is stronger than before, that is, a part stronger than the whole. The ends were loose at 2 feet 8 inches apart as before. The edge from which the part was intercepted, was lowermost, the weight was applied on the base above, it broke with 1129 lbs., whereas, in the other case it bore only 840lbs.

Remarks on the transverse strain.

BANKS makes his bar from the cupola, when placed on bearings 3 feet asunder, and the ends loose, to bear 864lbs

Now all my bars were cast from the cupola, the difference was therefore - - - 33lbs.

I adopted a space of 2 feet 8 inches asunder, as being more convenient for my apparatus. The strength of the different bars, all cases being the same, approaches nearly to the

theory, which makes the comparative values as the breadths multiplied into the squares of the depths. The halves of the bars were tried, merely to keep up the analogy. The bar of 4 inches deep, however, falls short of theory by 365 lbs. It is evident we cannot extend the system of deepening the bar much farther, nor does the theory exactly maintain in the case of the equilateral triangle by - - 243lbs. The diagonal position of the square bar, is actually worse than when laid on its side, contrary to many assertions.

The same quantity of metal in the feather edged bar, was not so strong as in the 4 inch bar.

The semi-elliptical bar, exceeded the 4 inch bar, although taken out of it. The parabolic bar came near it.

The bar made fast at both ends, I suspect must have yielded, although the ends were made fast by iron straps. The experiments from EMERSON, on solids of different forms might be made; but the time and trouble these experiments have already cost, have compelled me to relinquish farther pursuits for the present. If, however, in the absence of better, they are worthy of the indulgence of the Royal Society, it will not only be a consolation to me that my labours merit their attention, but a farther inducement to prosecute the investigation of useful facts, which, even in the present advanced state of knowledge, will yet admit of addition.

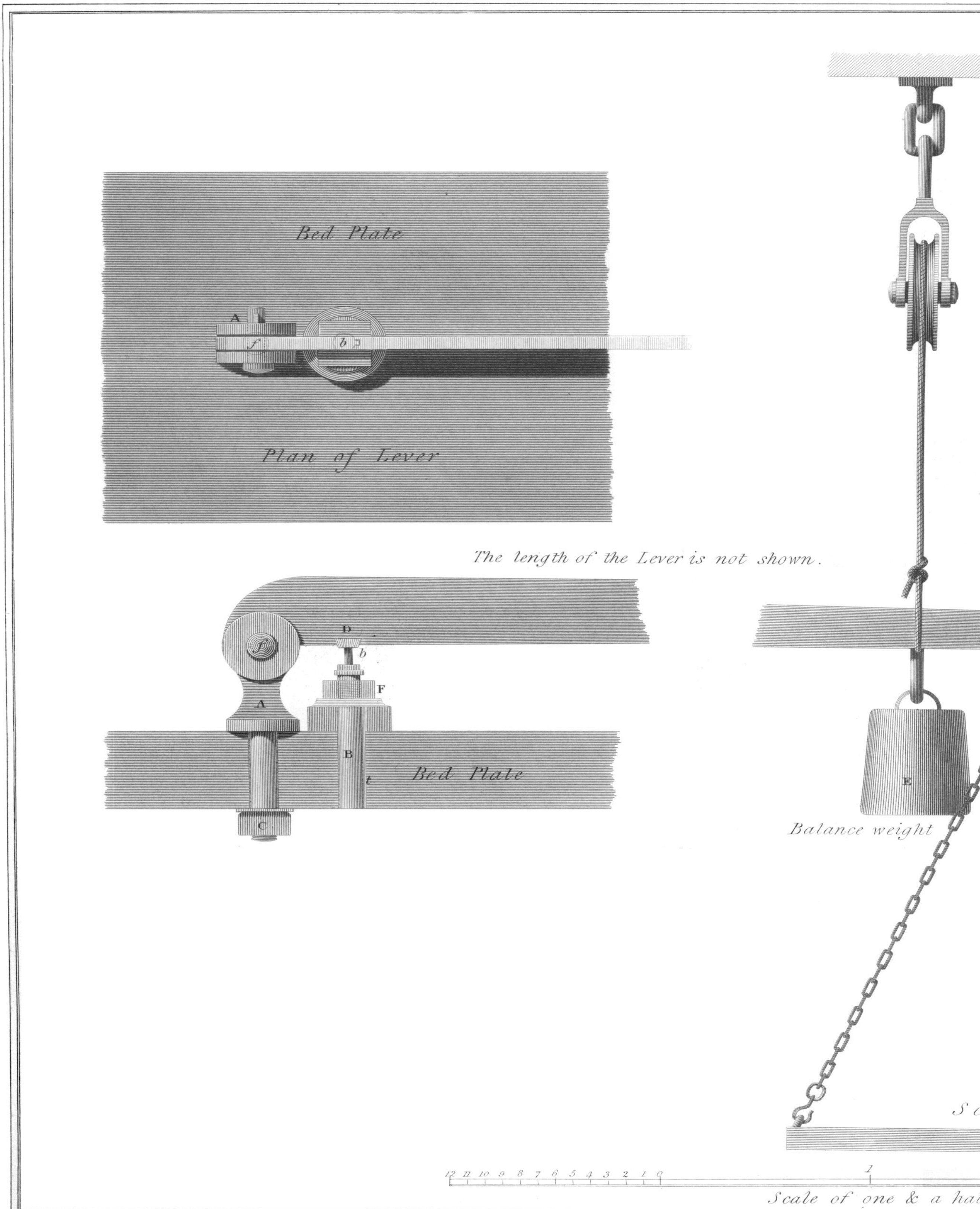
I am, with much respect,

GEORGE RENNIE.

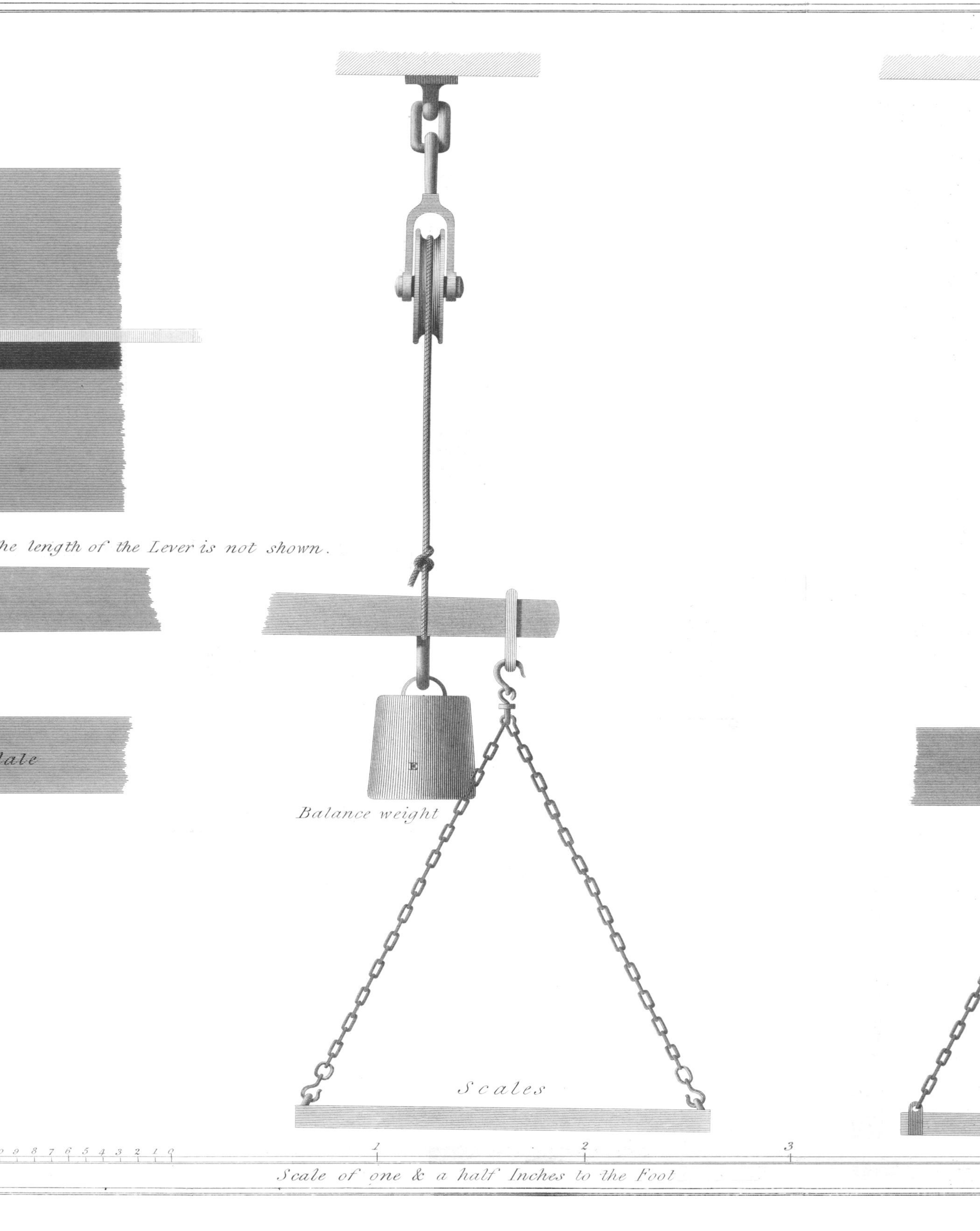
Since my return to England, I find that a set of experiments have been undertaken by Mr. PETER BARLOW, of the

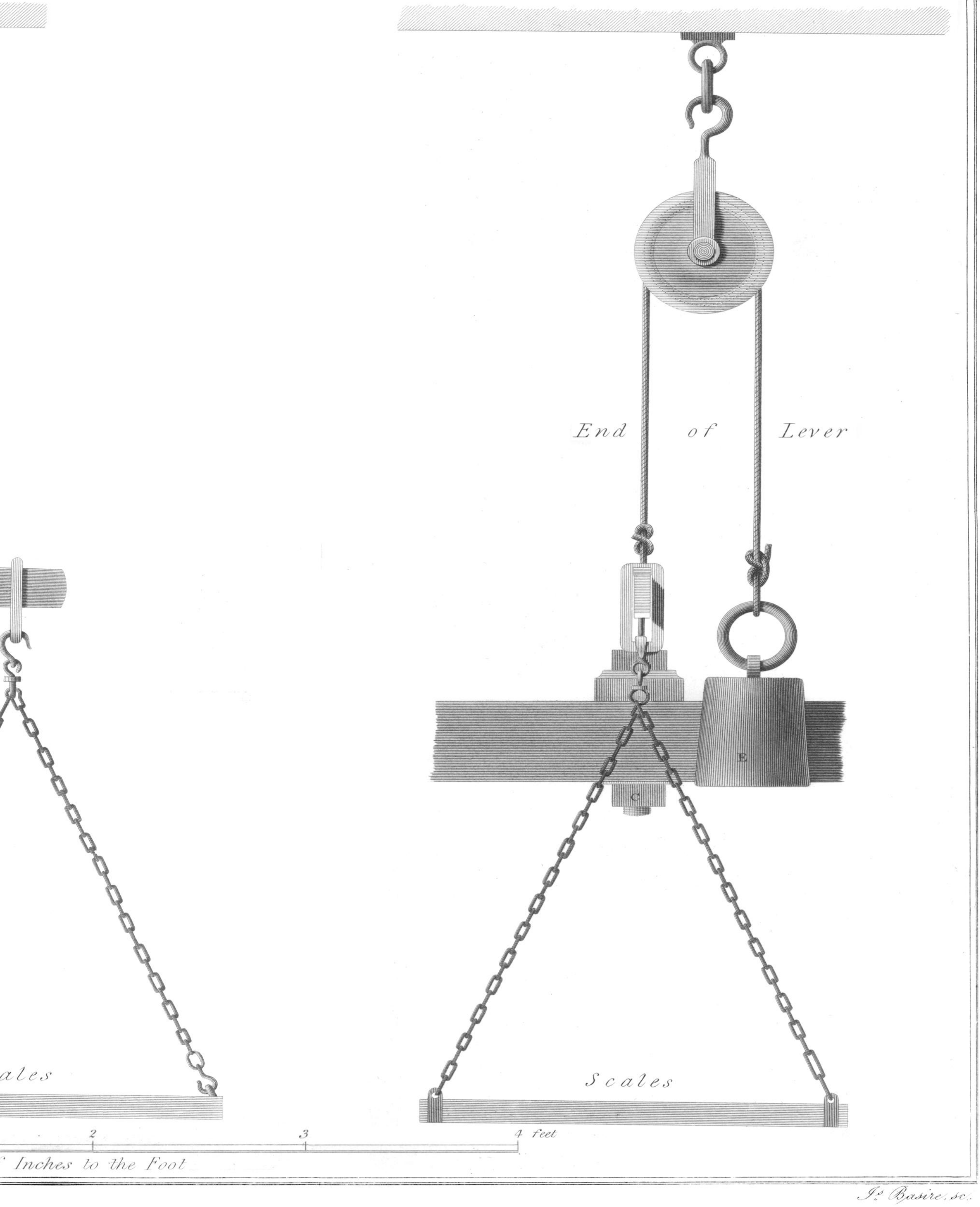
Royal Military Academy. They are very interesting, but contain no experiments on the repulsive power of bodies, and consequently, my communication is not altogether superseded, although a space of seven months has elapsed since this was written. G. R.

London, Dec. 28, 1817.

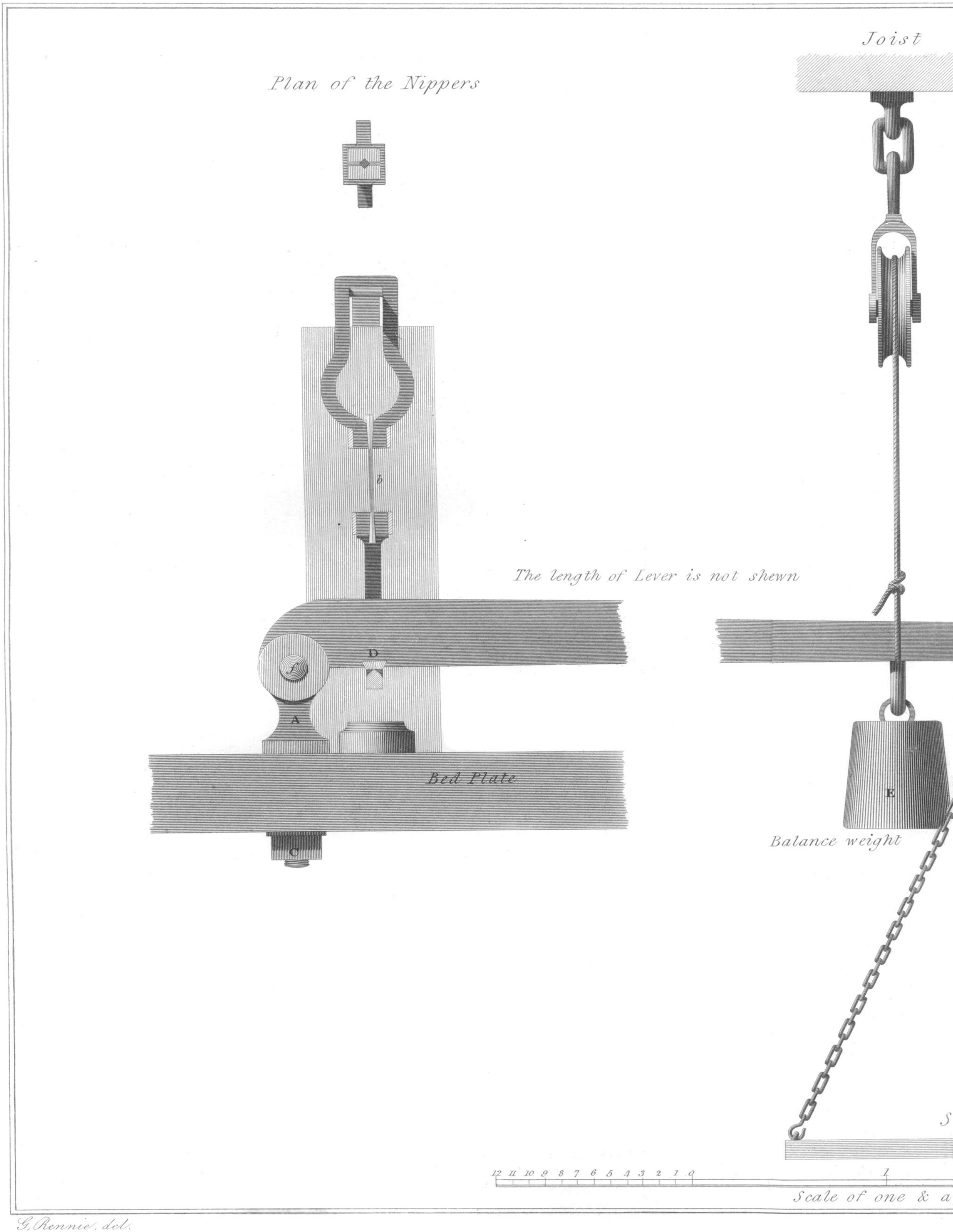

Bed Plate
A
f
b
Plan of Lever
The length of the Lever is not shown.
D
b
F
A
B
t
Bed Plate
C
E
Balance weight
12 11 10 9 8 7 6 5 4 3 2 1 0
1
Scale of one & a

G. Rennie, del.

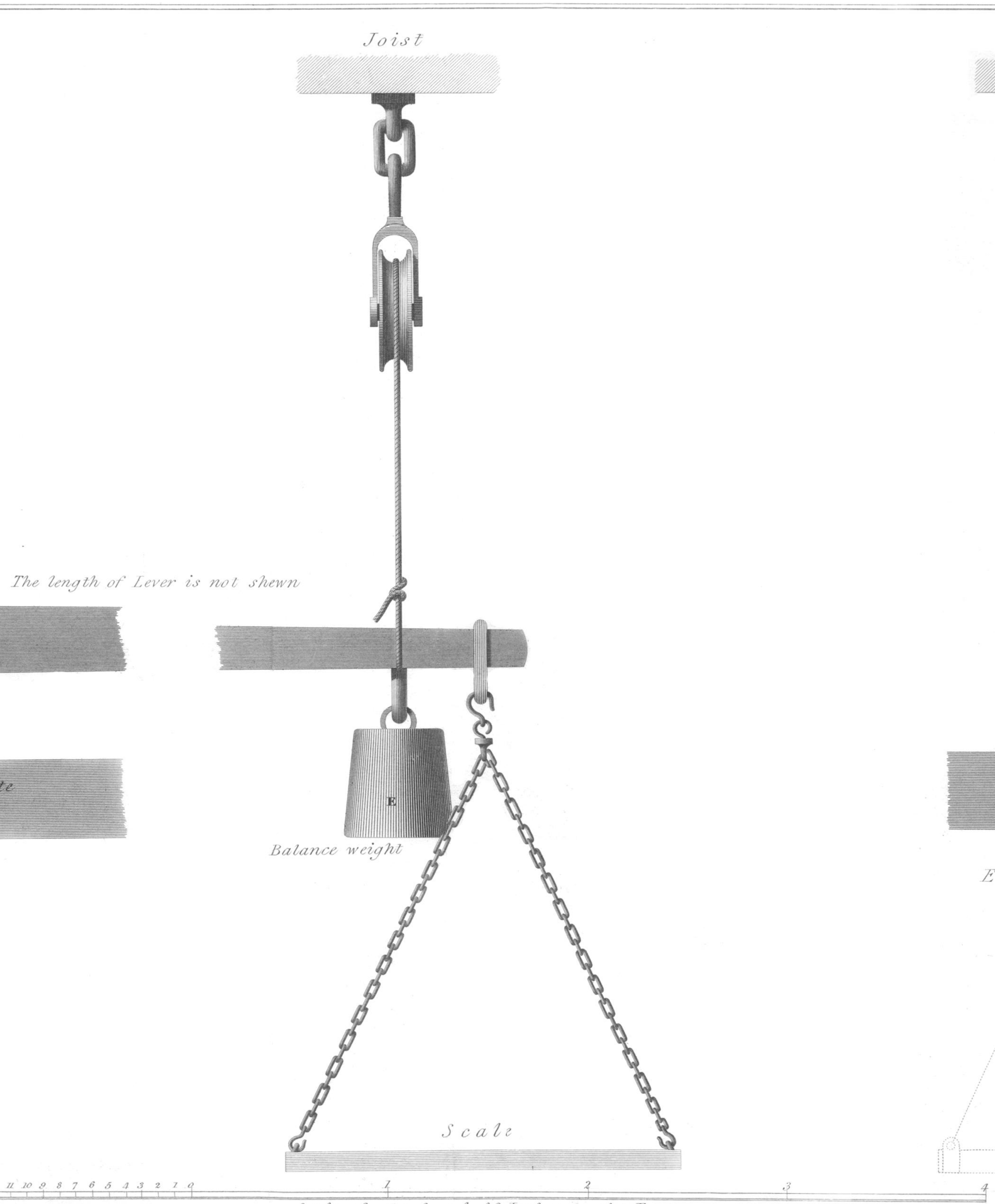

he length of the Lever is not shown.
ale
E
Balance weight
Scales
9 8 7 6 5 4 3 2 1 0
1
2
3
Scale of one & a half Inches to the Foot

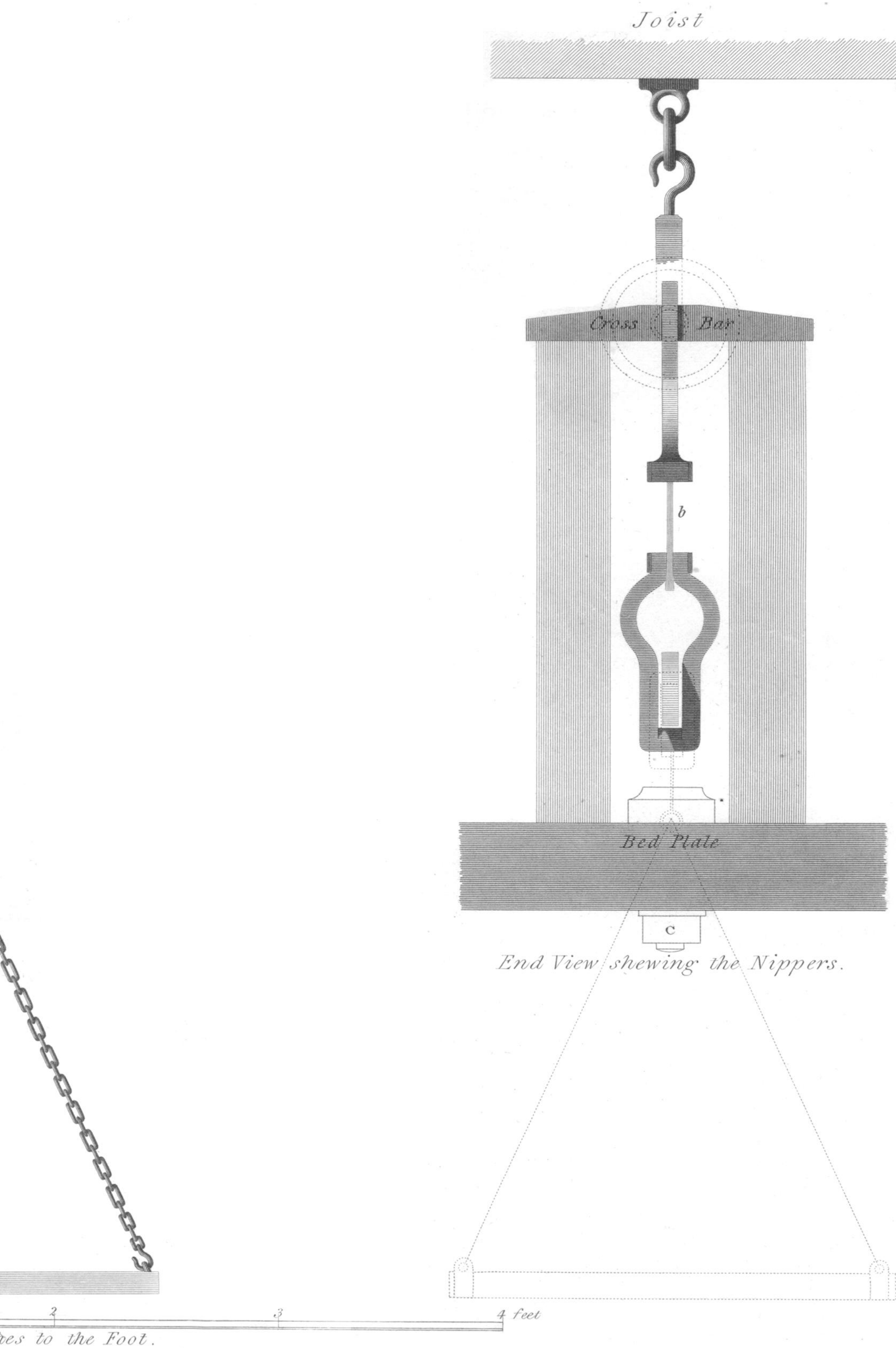


Jˢ Basire, sc.


Plan of the Nippers
Joist
b
The length of Lever is not shewn
D
A
Bed Plate
C
E
Balance weight
12 11 10 9 8 7 6 5 4 3 2 1 0
1
Scale of one & a

G. Rennie, del.


Joist
The length of Lever is not shewn
E
Balance weight
Scale
11 10 9 8 7 6 5 4 3 2 1 0
1
2
3
4
Scale of one & a half Inches to the Foot.



End View shewing the Nippers.

J. Basire sc.